Step 4 (boundaries of the study) establishes the geographical extent of the investigation area and the potential receptors of concern that need to be considered by the study.

The geographical limits (ie. spatial boundaries) appropriate for the data collection and decision making in this investigation are:

- The northern boundary of the Site (the up-gradient boundary);
- Burren Street to the west of the Site;
- The edge of the Illawarra railway line to the east of the Site;
- The edge of railway land along Railway Parade to the south of the Site; and
- The upper parts of the semi-confined aquifer that occurs near the clay / fractured shale bedrock contact.

The potential receptors of ground contamination from the Site, as mentioned previously in **Section 5.6.4**, are considered to be:

- Future commercial/industrial users of the Site by RailCorp workers;
- Future maintenance / construction workers at the Site and surrounding areas;
- The community who live in residential land adjacent to the western boundary of the Site; and
- Users of any groundwater extracted from wells down-gradient of the Site.

Step 5 (decision rules) adopted by the investigation is to assess the need for additional risk assessment, remediation, or management controls in the event that contamination from the Site is found to exceed DEC-endorsed environmental criteria. This approach is consistent with the methodology described in the ANZECC & NHMRC (19992) guidelines for managing contaminated Sites, which is the basis for the SEPP55 and NEPM (1999) guidelines. This decision rule has been used as the basis for the Site-specific risk assessment.

Step 6 (tolerable limits on decisions errors) defines how the quality of the data collected by the investigation are to be assessed. These criteria are summarised in **Table 10**.

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- Table 10 Data Quality Evaluation Criteria

Feature	Evaluation Criteria
Documentation and data completeness	• Site conditions properly described • Sampling locations properly described and located • Completion of field records, calibration results, chain of custody documentation, laboratory test certificates from NATA-registered laboratories • Samples are collected from all areas of potential environmental concern along the foreshore boundaries • Samples are tested for all potential contaminants of concern • Sampling events cover worst case conditions on more than one occasion
Data comparability	• Use of appropriate techniques for the sampling, storage and transportation of samples • Use of NATA certified laboratory using NEPM procedures. • Use of NATA certified check laboratory
Data representativeness	• Collection of representative samples from each sampling location
Precision and accuracy for sampling and analysis	• Use of properly trained and qualified field personnel • Blind field duplicates to be collected at a minimum rate of 1 in 10 • RPD's to be less than 30% for inorganic and 50% for organic analyses • Acceptable quality of rinsate blanks • Achieve laboratory QC criteria

Step 7 (optimisation of the data collection process) is implemented by the investigation through the following means:

- Targeted sampling at the most suspect areas of the Site;
- The investigation was conducted to a level of accuracy and confidence that was consistent with the standards specified by the DEC in their guideline titled *'Contaminated Sites Sampling Design Guidelines'* (NSW EPA, 1995), other DEC guidelines, NEPM and associated documents;
- Location of groundwater monitoring wells at most suspect locations down-gradient of the contaminant plume;
- Re-sampling of the existing wells that will provide the best data coverage for the Site and surrounding areas; and
- Collection of passive air samples from the land having the highest potential for elevated volatile gas levels.

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7.2 Field Quality Assurance and Quality Control

The Quality Assurance and Quality Control (QA/QC) protocols used during the fieldwork for the Macdonaldtown Triangle are summarised in **Table 11**.

- Table 11 Field QA/QC

Field Procedure	QA Procedure Description
Sampling Team	The fieldwork was directed by Dr Ian Swane and managed by Christine Tropman, an experienced Environmental Scientist. Site personnel comprised only professionally qualified environmental scientists and engineers trained in conducting Site contamination investigations. In completing the field investigation, the Work and OH&S Plan provided a framework for meeting the Data Quality Objectives.
QA/QC System	All fieldwork was conducted in accordance with the Sinclair Knight Merz Standard Sampling Procedure and the company's ISO 9001 certified QA/QC system.
Borehole Logs	Borehole logs for each sampling location were prepared and provided in the Risk Assessment report.
Equipment Calibration	All equipment was calibrated prior to use in the field
Chain of Custody Forms	All samples were logged and transferred under appropriately completed Chain of Custody Forms.
Preservation	All samples were received at the laboratory in appropriately preserved containers, with preservation including packing samples with ice packs in eskies.
Rinsate Blanks	Rinsate blanks were collected at a rate of one per field day to determine if any cross contamination may have occurred during sampling, as specified given in Section 8 of Australian Standard AS4482.1-1997.
Blind Field Duplicates (for testing by Main Lab)	Blind field duplicate samples were prepared in accordance with procedures given in Section 8 of Australian Standard AS4482.1-1997. The frequency of blind field duplicate testing corresponds to at least 5% for both soil and groundwater samples (ie. 1 in 20 samples).
Split Samples (for Inter-Laboratory Testing)	Split samples were prepared in accordance with procedures given in Section 8 of Australian Standard AS4482.1-1997. The frequency of blind field duplicate testing corresponds to at least 5% for both soil and groundwater samples (ie. 1 in 20 samples).

7.3 Laboratory Quality Assurance and Quality Control

The primary and secondary laboratories used for this investigation were ALS and Amdel; both are NATA registered chemical laboratories for the specified tests, with the exception of analysis for speciated TPH, which was undertaken by Amdel, using method E1224, but is not covered by their NATA accreditation. All tests were undertaken in accordance with the NEPM (1999) and ANZECC (2000) water quality guidelines.

A data validation process was used to assess the effectiveness of the overall analytical process and to assess the use of data. **Table 12** outlines the data validation criteria, qualifications to the data and the overall QA/QC procedures used for the laboratory testing program.

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- Table 12 Laboratory QA/QC

Protocol	Description
Holding Times	Holding times are the maximum permissible elapsed time in days from the collection of the sample to its extraction and/or analysis. All extraction and analyses were completed within standard guidelines.
Reagent Blanks	The reagent blank sample is a laboratory prepared sample containing the reagents used to prepare the sample for final analysis. The purpose of this procedure is to identify contamination in laboratory reagent materials and assess any potential bias in sample analysis due to contaminated reagents. Contaminant concentrations must be below the analytical limits of detection in the reagents. Each analysis procedure was subject to a reagent blank analysis. The results of each indicated that the reagents were not contaminated.
Laboratory Duplicates	Laboratory duplicates are field samples that are split in the laboratory and subsequently analysed a number of times in the same batch. These sub-samples are selected by the laboratory to assess the accuracy and precision of the analytical method. ALS/Amdel undertook QA/QC procedures such as calibration standards, laboratory control samples, surrogates, reference materials, sample duplicates and matrix spikes. Intra-laboratory duplicates are performed on a frequency of 1 per 10 samples. The RPD of laboratory duplicates is 50 %, with all results within the specified criteria.
Laboratory Control Standard	A laboratory control standard is a standard reference material used in preparing primary standards. The concentration should be equivalent to a mid range standard to confirm the primary calibration. Laboratory control samples were performed on a frequency of 1 per 20 samples or at least one per analytical run.
Matrix Spikes / Matrix Spike Duplicates (MS/MSD)	MS/MSDs are field samples to which a predetermined stock solution of known concentration is added. The samples are then analysed for recovery of the known addition. Recoveries should be within the stated laboratory control limits of 70 to 130% and duplicates should have RPDs of less than 50%. The majority of RPD's were within accepted limits, with the exception of several samples which had RPD results marginally above 50%. These exceedances are not considered significant as they were close to the criteria and the majority of samples analysed were below or neat to the analytical detection limits. Laboratory control limits for phenol were consistently below the 70% criteria, ranging between 50-60%. This is not considered significant as all recorded phenol concentrations were below assessment criteria.
Blind Field Duplicates	Split samples were prepared in accordance with procedures given in **Section 7.2** of Australian Standard AS4482.1-1997. In total, 3 blind field duplicates and one triplicate water sample out of 34 samples analysed were collected. Field duplicate results are included in the summary of results tables and RPD calculations are included as Tables J - M. The majority of samples were below the RPD criteria for both organic (50%) and inorganic compounds (30%), with the following exceptions: ▪ Nickel at MW39D with an RPD of 40%; ▪ Zinc at MW39D with an RPD of 136.4%; ▪ Lead at MW04D with an RPD of 36.4%; ▪ Zinc at MW04D with an RPD of 35.8%; ▪ Pyrene at MW39D with an RPD of 120%; ▪ Benzene at MW04D with an RPD of 109.1; TPH C_{10}-C_{14} and TPH C_{15}-C_{28} at MW42D with RPDs of 95.7% and 100%, respectively. The nickel, lead, pyrene, benzene and TPH C_{10}-C_{14} RDP results are not considered to be significant, as concentrations are close to the analytical limits of the test methods. The zinc and TPH C_{15}-C_{28} RPD results are attributed to heterogeneity of samples. All results were below the water criteria except for benzene, although in this case the

Protocol	Description
	primary duplicate was within acceptable RPD criteria. A blind soil sample duplicate was analysed for BTEX and TPH. All RPDs were below 50% with the exception of C_{16}-C_{28} with an RPD of 367%. This result is not considered significant, as concentrations were close to the limits of the analytical test methods.
Surrogate Spikes	Surrogate spikes provide a means of checking, for every analysis, that no gross errors have occurred at any stage of the procedure leading to significant analyte loss. Recoveries should be within the stated laboratory control limits of 70 to 130%.
QA/QC Conclusion	The QA/QC indicators should either all comply with the required standards or show variations that are considered to have a significant effect on the quality of the data. Based on the scope and results of the quality checking, the laboratory results are considered to be consistent and indicate that the laboratory results are reliable.

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8 Investigation Levels

This section of the report describes the various environmental investigation levels that have been adopted by this study to identify those contaminants and environmental media that require evaluation as part of a Site-specific human health and ecological assessment.

As previously mentioned in Section 2.4.1, the ANZECC & NHMRC (1992) and NEPM (1999a) guidelines[3] define an 'Investigation Level' as "the concentration of a contaminant above which further appropriate investigation and evaluation will be required." Investigation Levels are used by to identify those contaminant(s) that should be further investigated as part of a site-specific risk assessment.

In this risk assessment for the Former Gasworks Site Investigation Levels have been defined for the three environmental media of concern at the site, as previously identified in Section 5.6.3, these being soil, groundwater and soil gas, together with aesthetics.

8.1 Soil Investigation Levels

8.1.1 Methodology

The NSW EPA has endorsed the use of the Soil Investigation Levels (SILs) given in the 1999 NEPM *'Schedule B(1) Guideline on the Investigation Levels for Soil and Groundwater'*. The guidelines provide both Health Based Investigation Levels (HILs) and Ecologically Based Investigation Levels (EILs) for a range of land uses.

As stated in the NEPM (1999a) guidelines, health based Investigation Levels should not be considered as clean up or response levels (the concentration of a contaminant for which some form of response is required to provide an adequate margin of safety to protect public health and/or the environment) nor are they desirable soil quality criteria. These values are to be used to assess existing contamination only and are intended to prompt a site-specific assessment when they are exceeded. In addition, relevant investigation levels need to be developed when:

- *Investigation Levels* are not available for contaminants of concern and/or data to enable the derivation of guideline values;
- Site conditions, receptors and/or exposure pathways differ significantly from those assumed in the derivations of the health based or ecological investigation levels; and

[3] NEPC. 1999. "Schedule B(4) Guideline on Health Risk Assessment Methodology". National Environment Protection (Assessment of Site Contamination) Measure 1999.

- There are significant ecological concerns (eg. critical or sensitive habitat, threatened or endangered species, parklands or nature reserves).

National Environment Health Forum (NEHF) HILs are given in the NEPM for 4 types of land uses:

- A–'Standard' residential with garden/accessible soil (home-grown produce contributing less than 10% of vegetable and fruit intake; no poultry): this category includes children's day-care centres, kindergartens, preschools and primary schools
- D–Residential with minimal opportunities for soil access: includes dwellings with fully and permanently paved yard space such as high-rise apartments and flats
- E–Parks, recreational open space and playing fields: includes secondary schools
- **F–Commercial/industrial: includes premises such as shops and offices as well as factories and industrial Sites.**

The HIL's given in the NEPC (1999a) guideline cover most of the potential contaminants of concern that are relevant to this investigation. The analytes not covered include TPH/BTEX, OPPs, asbestos, VOCs and most SVOCs. Criteria for these contaminants have been sourced from:

- NSW EPA (1994) *'Guidelines for Assessing Service Station Sites'* for petroleum hydrocarbons (TPH/BTEX). While these guidelines are for *'sensitive land use'*, such as standard residential, the NSW EPA has required these criteria be applied to other land uses unless a Site-specific risk assessment justifies the use of different criteria;
- The NSW EPA (1998) Site Auditor Guidelines included an EIL for phenol;
- Department of Health issued a letter in September 2000 to the NSW EPA advising that there be no free asbestos fibres at the ground surface; and
- The Dutch 2000 Intervention Values[4] and where not available the US EPA Table 9 Preliminary Remediation Goals (PRG)[5] have been adopted for OPPs, VOCs and SVOCs that have no relevant Australian Guidelines.

As previously mentioned in **Section 2.1**, the Former Gasworks Site will remain the property of RailCorp and continue to be zoned to allow commercial/industrial land, although it is not known what site activities will occur or if any structures/ buildings will be established on the site. This study has therefore adopted the HIL(F) soil criteria for the Site, although other criteria will be considered. The EILs provided in the NEPM (1999) guidelines represent Provisional Phytotoxicity criteria that are protective of flora. These criteria are not considered significant at this Site as there

[4] http://www2.vrom.nl/Docs/internationaal/annexS_I2000.pdf
[5] www.epa.gov/region09/waste/sfund/prg/files/02table.pdf

is no significant vegetation present on the Site, however the criteria will be considered due to possible future landscaping requirements.

Soils that have contaminant concentrations less than both the HILs and EILs are considered to pose no hazard to both users of the Site and flora at the Site, and require no further investigation. Soils that have contaminant concentrations that exceed either the HIL or EIL require further investigation and evaluation as part of the site-specific risk assessment, as recommended in the ANZECC & NHMRC (1992) and NEPC (1999) guidelines. A summary of these criteria for the potential contaminants of concern, together with the NEPM values for the other land uses, is provided in **Table 13**. Typical background ranges for these contaminants, which are recommended in the NEPM (1999) guidelines, are also provided in the table.

- Table 13 Soil Investigation Levels (mg/kg)

Substances	Health Investigation Levels (HILs)						Ecological Investigation Levels (EILs)		Back/ ground Ranges[6]
	A[1]	B[2]	C[3]	D	E	F	REIL[4]	Interim Urban[5]	
METALS/METALLOIDS									
Arsenic (total)	100			400	200	500		20	1-50
Barium								300	100-3000
Beryllium	20			80	40	100		3	1
Cadmium	20			80	40	100		3	1
Chromium (III)	12%			48%	24%	60%		400	
Chromium (VI)	100			400	200	500		1	
Chromium (Total *7									5-1000
Cobalt	100			400	200	500			1-40
Copper	1000			4000	2000	5000		100	2-100
Lead	300			1200	600	1500		600	2-200
Manganese	1500			6000	3000	7500			
Methyl Mercury	10			40	20	50			
Mercury (inorganic)	15			60	30	75		1	0.03
Nickel	600			2400	600	3000		60	5-500
Vanadium								50	20-500
Zinc	7000			28000	14000	35000		200	10-300
ORGANICS									
Aldrin + Dieldrin	20			40-	20	50			
Chlordane	50			200	100	250			
DDT + DDD + DDE	200			800	400	1000			
Heptachlor	10			40	20	50			
Polycyclic aromatic Hydrocarbons (PAHs)	20			80	40	100			
Benzo(a)pyrene	1			4	2	5			
Phenol	8500			34000	17000	42500		70	
PCBs Total	10			40	20	50			
MONOCYCLIC AROMATIC HYDROCARBONS									
Benzene	1								
Toluene	130	130	130	130	130	130		1.4	
Ethyl benzene	50	50	50	50	50	50		3.1	
Total Xylenes	25	25	25	25	25	25		14	